Schel-chélb Estuary

2001 Annual Monitoring Report

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March 2002

Washington State Department of Transportation

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Executive Summary

The following report summarizes project activities completed by the Washington State Department of Transportation (WSDOT) Wetland Monitoring Program at the Schel-chélb estuary in 2001 and 2002. Activities include wildlife, vegetation, soil, topography, and water quality surveys. As specified in the *Operations, Maintenance, and Monitoring Plan* (*OMMP*) *for the West Harbor Operable Unit Wykoff/Eagle Harbor Superfund Site* (Hart Crowser 1997), formal site monitoring continues in 2003 and 2006, with distribution of the monitoring report by March 31 of each respective, subsequent year. An informal, qualitative assessment of selected wetland parameters including ocular estimates of undesirable (invasive) species cover will occur in summer 2002, 2004, and 2005.

A topographic survey of the Schel-chélb estuary was conducted in February 2002. Survey results show that the area of tidal inundation is 2.27 acres with an average slope of 13:1 (horizontal to vertical) (h:v). These results compare favorably to performance standards that require two acres of tidal inundation and an average slope flatter than 7:1 (h:v).

In February 2002, the elevation of an open culvert that runs beneath Baker Road and connects to an adjacent forest wetland was measured. Records show the culvert rises from an elevation of 11.363 feet at the east end to 11.559 feet on the west. These findings indicate the performance standard that requires an open culvert with zero percent slope and an invert elevation of +11.0 feet has not been achieved.

A hand refractometer was used to measure salinity in the Schel-chélb estuary during a high tide in February 2002. A salinity reading of 20 parts per thousand (ppt) was recorded, which meets the site performance standard that requires a mixohaline environment within the constructed estuary.[1]

Soil samples were collected at 30 locations across the tide flat in February 2002. A composite sample was sent to a lab for particle size analysis. Test results show the sample contains 15.6% silt and 2.1% clay sized particles, for a total 17.7%. In 1998, a similar sample contained 9.0% silt and 2.4% clay sized particles, for a total 11.4%. Using the Unified Soil Classification Guidelines (ASTM 2001), these results indicate soil in the intertidal flat has achieved the performance standard that requires a change from sand to silty sand.

Vegetation surveys using the line intercept, point-line, and point frame methods were completed in the intertidal saltmarsh and upland (wetland buffer) zones of the Schel-chélb estuary in August 2001.[2] In general, monitoring results indicate Year 5 (2001) performance standards have been achieved, as plant communities are well established in both wetland zones. Records show native wetland plants provide 73% (CI 0.90 ± 0.06) aerial cover in the intertidal saltmarsh, which compares to the performance standard of at

[1] Salinity readings from 0.5 to 30 ppt indicate a mixohaline environment (Cowardin et al. 1979).
[2] Methods are based on techniques described in Bonham (1989), Elzinga et al. (1998), Coulloudon et al. (1999), Krebs (1999), Zar (1999), and other sources.

least 75% cover by Year 5.[3] The wetland buffer supports 56% (CI 0.90 ± 0.13) aerial cover of native trees and shrubs, which compares favorably to the performance standard of at least 50% cover by Year 5. Aerial cover of undesirable (invasive) plant species was 5% (CI 0.80 ± 0.27), which meets the performance standard of less than 10%.

Appendix A compares development of vegetative communities in the intertidal saltmarsh and upland zones to the original Schel-chélb planting plan. This comparison indicates plant communities in both zones are developing as intended.

Five bird surveys were conducted at the Schel-chélb estuary and Harper reference site from April through July 2001. The point count method was used to document both species richness and relative abundance. Although records show similar types of birds are present at both sites, values for species richness and species diversity are higher for the Schel-chélb mitigation site. In addition, while no upland birds were present during bird surveys at the Harper reference site, three were recorded in the upland buffer at Schel-chélb. These results indicate performance standards that call for similar bird species composition, richness, and diversity at the mitigation and reference sites have been achieved.

Benthic macroinvertebrate samples were collected from four locations across the Schel-chélb estuary in September 2001. Invertebrates from these samples were identified to the family taxon level. Seventeen invertebrate families were present in samples collected at the estuary. This result exceeds the performance standard that requires benthic invertebrate family richness values of at least 25 percent the number at the Harper reference site in Year 2 (1998). Thirteen invertebrate families were identified from samples collected at the Harper estuary in 1998.

Data collected from the Schel-chélb estuary and Harper reference site in 2001 and 2002 are available upon request from the Wetland Monitoring Program.

[3] Most cover values are presented with their corresponding statistical confidence interval. For example, the estimated aerial cover of native saltmarsh plants is 73% (CI 0.90 ± 0.06). This notation means we are 90% confident that the true aerial cover value is between 68.6% and 77.4%.

Introduction

Background

The Schel-chélb mitigation site serves as partial compensation for loss of aquatic habitat resulting from cleanup activities associated with the Wyckoff/Eagle Harbor Superfund Site. This restoration effort occurs on the site of a historical estuary that was filled during road construction at the turn of the last century.

Schel-chélb is located approximately one-quarter mile west of Lynnwood Center on Point White Drive along the southwestern edge of Bainbridge Island, Washington. It is 2.1 miles southwest of the Superfund Site (Map 1, p. 4). This restoration project is part of the South Bainbridge Estuarine Wetland and Stream Relocation Project proposed by the U.S. Fish and Wildlife Service (USFWS) (Amato 1995). WSDOT is responsible for the mitigation plan and for the design, construction, and monitoring of the estuary. USFWS is responsible for the mitigation plan and for the design, construction, and monitoring of the stream restoration portion of the overall project. The Schel-chélb mitigation site is designed and constructed to be a naturally functioning estuarine wetland regardless of the success of the stream restoration project.

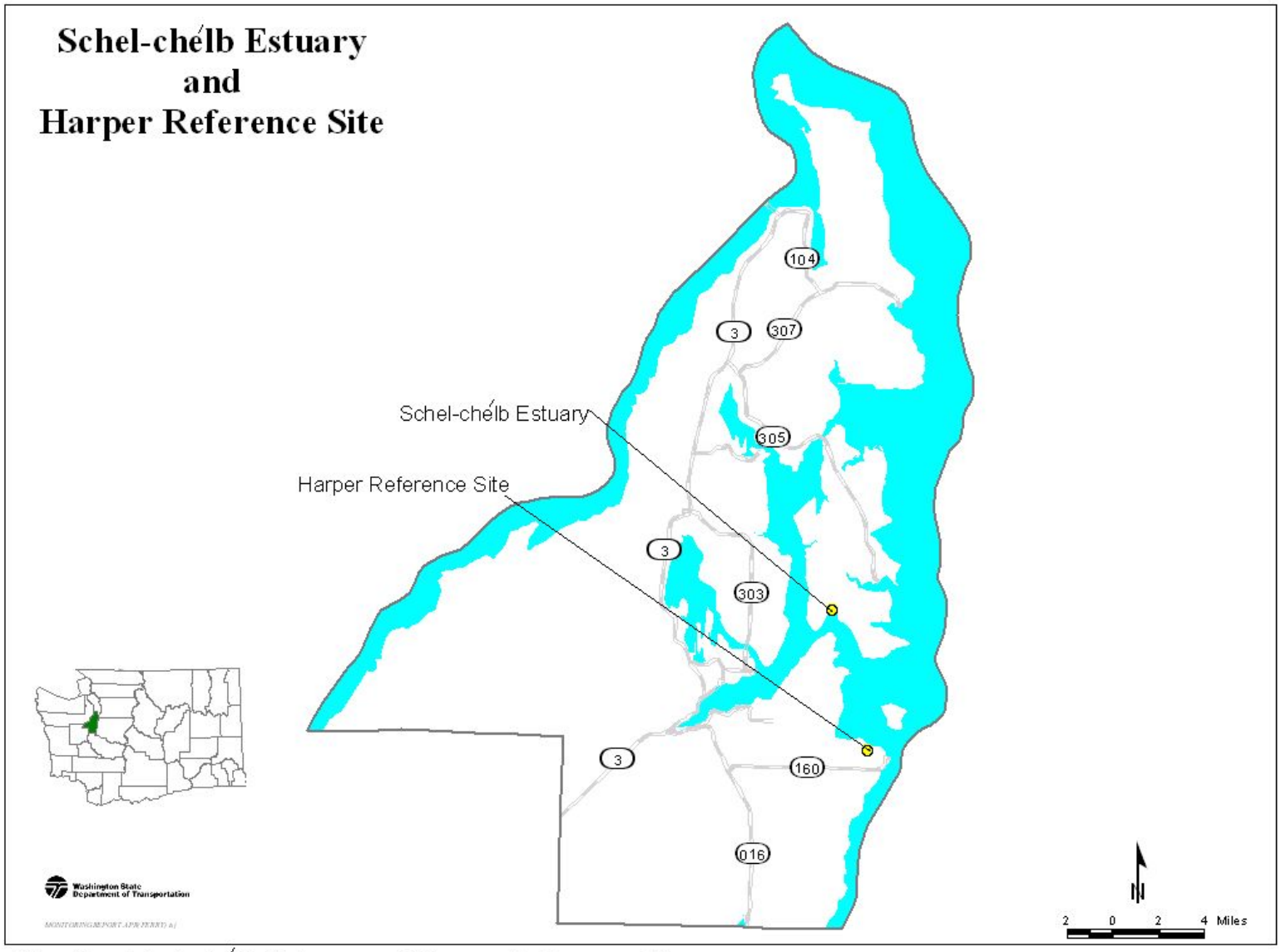
The Schel-chélb mitigation site is modeled after a small estuary near the town of Harper on the Kitsap Peninsula. From Schel-chélb, the Harper estuary is located 6.25 miles south across Rich Passage and approximately one mile northwest of the Southworth ferry terminal (Map 1, p. 4). The Harper wetland will be used as a reference site for comparisons of vegetative cover, soil texture and composition, bird life, and benthic macroinvertebrates at the mitigation site.

Mitigation Site Description

The Schel-chélb mitigation site is intended to provide one acre of upland buffer and two acres of tidally inundated estuarine wetland. Measurements at the reference site were used to determine the elevation of planting areas in the constructed estuary. Schel-chélb has been divided into the following three zones:

- Intertidal flat – Approximately 34% of the wetland has been designed as intertidal flat with elevations below +10.0 feet.
- Low intertidal saltmarsh – Approximately 58% of the wetland has been designed as low intertidal saltmarsh between elevations +10.0 and +12.5 feet.
- High intertidal saltmarsh – Approximately 8% of the wetland has been designed as high intertidal saltmarsh between elevations +12.5 and +13.0 feet.

The south end of the mitigation site is connected to Puget Sound via a 64-foot long, bottomless box culvert (12 feet wide and 6 feet high) that passes under Point White Drive and connects to Rich Passage. The restored stream at the north end of the mitigation site supplies freshwater to the estuary.



Map 1: Schel-chélb Estuary and Harper Reference Site

Privately owned land surrounds the estuary to the north, east, and west. Point White Drive borders the site along its southern boundary, separating the site from Rich Passage to the south. Private homes are present within several hundred yards of the site to the east and west. A mix of deciduous and coniferous forest surrounds these homes. The wooded area is most extensive to the north as it follows the restored stream.

Goals, Objectives, and Performance Standards

The goals, objectives, and performance standards listed below are excerpted from the *Schel-chélb Estuary Site Wetland Construction/Restoration Plan* (Swanson et al. 1998). Year 5 (2001) performance standards are addressed in this report. Companion sampling objectives follow where appropriate.

The primary goal of the Schel-chélb mitigation effort is to restore as closely as possible the intertidal and estuarine habitats that historically existed at this location. A self-sustaining, functional wetland system with intertidal flats and intertidal saltmarsh habitats is the desired outcome. This site is intended to provide wildlife habitat, fish passage, and food-chain support functions.

Amato (1995) enumerated ecological objectives for the estuary which have been reorganized into the five objectives below:

- Restore tidal conditions to approximately 2.0 acres of historical tidal wetland on Bainbridge Island.
- Replace an existing Category III wetland exhibiting low vegetative diversity and minimal wildlife use with a higher quality tidal wetland by restoring native tidal wetland plant communities of the type that historically existed on the site.
- Provide intertidal habitat for wildlife species.
- Provide an increase in habitat attributes (e.g., prey species, cover, overwintering area) for juvenile salmonids and other estuarine fish.
- Enhance an existing adjacent brackish marsh by improving tidal flow-through and removing barriers to fish passage between the project site and the existing marsh.

The Harper reference site was sampled during the first year of formal monitoring at the Schel-chélb estuary in 1998. Changes to WSDOT monitoring methods required re-sampling of the vegetative community using new monitoring techniques in 2001. Methods used to monitor the Harper estuary are described in Appendix B. Where indicated below, monitoring results from the Harper reference site will be used to evaluate site development at the Schel-chélb estuary.

Objective 1: Tidal Conditions
Restore tidal conditions to approximately 2.0 acres of historical tidal wetland on Bainbridge Island. This objective includes developing appropriate site elevations and a connection to marine waters at the estuary. Site topography, soil texture, salinity, tidal

inundation patterns, and areal extent of vegetated areas will be measured for comparison with the design plans and measures at the Harper reference site.

Performance Standards:
At the end of the first year:

1. Topography - As-built plan sheets based on a survey of the site show the contours and elevation are constructed as shown on the design plans and results in a tidally inundated estuary of 2.0 acres or greater.
2. Salinity - Conductivity measured at high tide with a refractometer indicates a mixohaline environment.
3. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.
4. Vegetated Areas - The proportion of unvegetated flat, vegetated tidal flats, and vegetated uplands are similar to the design plans.

After 5 years:

1. Topography - A survey of the site shows a tidally inundated estuary of 2.0 acres or greater.
2. Soil Texture - Soil texture shows accumulation of fine silts and a change from sandy to silty sand substrate.
3. Salinity - Conductivity measured at high tide indicates a mixohaline environment.
4. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.[4]
5. Vegetated Areas - The proportion of unvegetated flat, vegetated tidal flats, and vegetated uplands are within 15% of the design plan proportions.[5]

After 10 years:

1. Topography - A survey of the site shows a tidally inundated estuary of 2.0 acres or greater.
2. Soil Texture - Soil texture shows continued accumulation of fine silts.
3. Salinity - Conductivity measured at high tide indicates a mixohaline environment.
4. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.
5. Vegetated Areas - The proportion of unvegetated flat, vegetated tidal flats, and vegetated uplands are within 20% of the design plan proportions.

Objective #2: - Vegetation Communities
Replace an existing Category III wetland exhibiting low vegetative diversity and minimal wildlife use with a higher quality wetland by restoring native tidal wetland plant communities of the type that historically existed on the site. The Harper estuary will be used as a reference for plant community development.

[4] Tide stage data was collected in 1998. Results show the culvert under Point White Drive is of sufficient size to allow for full, unimpeded tidal exchange between the estuary and Rich Passage (Tanner 1998).
[5] Following an agreement with the Environmental Protection Agency (EPA), the OMMP was amended in 1999 to reflect changes in the planting schedule for the mitigation site (WSDOT 1999). These changes invalidate requirements in Performance Standard 5 (Objective 1) for monitoring Years 5 and 10.

Performance Standards:
At the end of the first year following construction:
1. At least two wetland classes, intertidal flat and intertidal saltmarsh, are established on the site.
2. The upland portion of the excavation site is planted with native tree and shrub species as specified in the Restoration Plan (Swanson et al. 1998).[6]

After 5 years:
1. Aerial vegetative cover of native saltmarsh plants is at least 75% in the intertidal saltmarsh.

   Sampling Objective: To be 80 percent confident mean aerial cover estimates for native saltmarsh plants are within 20 percent of the true species cover value.

2. Aerial vegetative cover of native trees and shrubs is at least 50% in the upland portion of the site.

   Sampling Objective: To be 80 percent confident mean aerial cover estimates for native trees and shrubs in the upland buffer are within 20 percent of the true cover value.

3. Aerial coverage by undesirable aquatic species including cordgrass (*Spartina* spp.) is less than 10%.

   Sampling Objective: To be 80 percent confident mean aerial cover estimates for undesirable aquatic species are within 20 percent of the true cover value.

After 10 years:
1. Aerial vegetative cover of native saltmarsh plants is at least 85% in the intertidal saltmarsh.
2. Aerial vegetative cover of native trees and shrubs is at least 70% in the upland portion of the site.
3. Aerial coverage by undesirable aquatic species including cordgrass (*Spartina* spp.) is less than 10%.

Objective #3: - Wildlife Habitat
Provide intertidal habitat for wildlife species. Wildlife habitat for the wetland dependent and other species will be increased as compared to the existing habitat value of the site. Creation of habitat will focus on increasing both habitat diversity (number of habitat types present) and habitat complexity (number and extent of canopy levels).

Perching, nesting and foraging opportunities for passerine birds will be provided in the upland forested area. The intertidal saltmarsh and the unvegetated flats will provide feeding areas for aerial-searching birds, shorebirds, and waterbirds.

[6] Evidence of plant colonization through all zones of the restoration site led to a proposed managed succession approach to revegetation of the estuary (WSDOT 1999). In May 1999, the planting schedule described in the Restoration Plan (Swanson et al. 1998) was amended to reflect this change.

Performance Standards:
After 5 years:
1. The numbers and species and types of birds associated with saltmarsh habitats will be similar to those observed at the Harper reference site in year one.
2. The number of bird species using the adjacent upland habitats will be at least one-third of the number using the Harper site in year one.

After 10 years:
1. The numbers and species and types of birds associated with saltmarsh habitats will be similar to those observed at the Harper reference site in year one.
2. The number of bird species using the adjacent upland habitats will be at least two-thirds of the number using the Harper site in year one.

Objective #4: - Fish Habitat and Food-Chain Support
Provide an increase in habitat attributes (e.g., prey items, cover, overwintering area) for juvenile salmonids and other estuarine fish. Provide access for adult fish to the stream portion of the project by way of the fish passage structures at the north end of the estuary. Salinity, site topography, and soil texture measured under Objective 1 are important to providing appropriate fish habitat.

Performance Standards:
At the end of the first year following construction:
1. Topography - As-built plan sheets based on a survey of the site show the contours and elevation are constructed as shown on the design plans and results in a tidally inundated estuary of 2.0 acres or greater.
2. Salinity - Conductivity measured at high tide with a refractometer indicates a mixohaline environment.
3. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.

After 5 years:
1. Topography - A survey of the site shows a tidally inundated estuary with average slopes flatter than 7:1 (h:v).
2. Soil Texture - Soil texture shows accumulation of fine silts and a change from a sandy to silty sand substrate.
3. Salinity - Conductivity measured at high tide indicates a mixohaline environment.
4. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.
5. Benthic invertebrate species richness is at least 25% of the number of species at the Harper site in year one.[7]

After 10 years:
1. Topography - A survey of the site shows a tidally inundated estuary with average slopes flatter than 7:1 (h:v).

[7] Benthic macroinvertebrates will be identified to the taxon level family for *Polychaeta, Mollusca,* and *Crustacea*. All benthic macroinvertebrate samples collected at the Harper reference site and Schel-chélb mitigation site will be archived by WSDOT for future reference and identification to species as desired and/or agreed upon by WSDOT and EPA (Swanson et al. 1998).

2. Soil Texture - Soil texture shows continued accumulation of fine silts.
3. Salinity - conductivity measured at high tide indicates a mixohaline environment.
4. Tidal Inundation - Tide heights and periods are similar to NOAA predicted heights.
5. Benthic invertebrate species richness is at least 50% of the number of species at the Harper site in year one.

Objective #5: - Fish Access to Marsh
Enhance an existing brackish marsh west of Baker Road by improving tidal flow-through and removing barriers to fish passage between the project site and the existing marsh. An existing culvert will be replaced with a 40-foot long 24-inch diameter culvert set at 0% slope and an invert elevation of +11.0 feet MLLW.

Performance Standard:
At the end of the first year following construction:
- The culvert under Baker Road shall be open and set at 0% slope and an invert elevation of +11.0 feet MLLW.

After 5 years:
- The culvert under Baker Road shall be open and provide fish passage at tidal elevations greater than +11.5 feet MLLW.

After 10 years:
- The culvert under Baker Road shall be open and provide fish passage at tidal elevations greater than +11.5 feet MLLW.

Methods

A topographic survey of the Schel-chélb mitigation site was conducted in February 2002. Slope and total acreage of the tidally inundated estuary were measured. The elevation of a culvert that runs beneath Baker Road and connects to an adjacent forest wetland was measured.

Soil samples were collected from 30 different locations across the tide flat in February 2002. A 110-meter baseline was placed along the length of the flat. Using a systematic random sampling method, six temporary sampling transects were placed perpendicular to the baseline. Soil data were collected from five random locations along each transect. At each location, a core sample of the substrate was extracted. A composite sample was sent to a lab for particle size analysis using methods described in the American Society for Testing and Materials Practice (ASTM 1998).

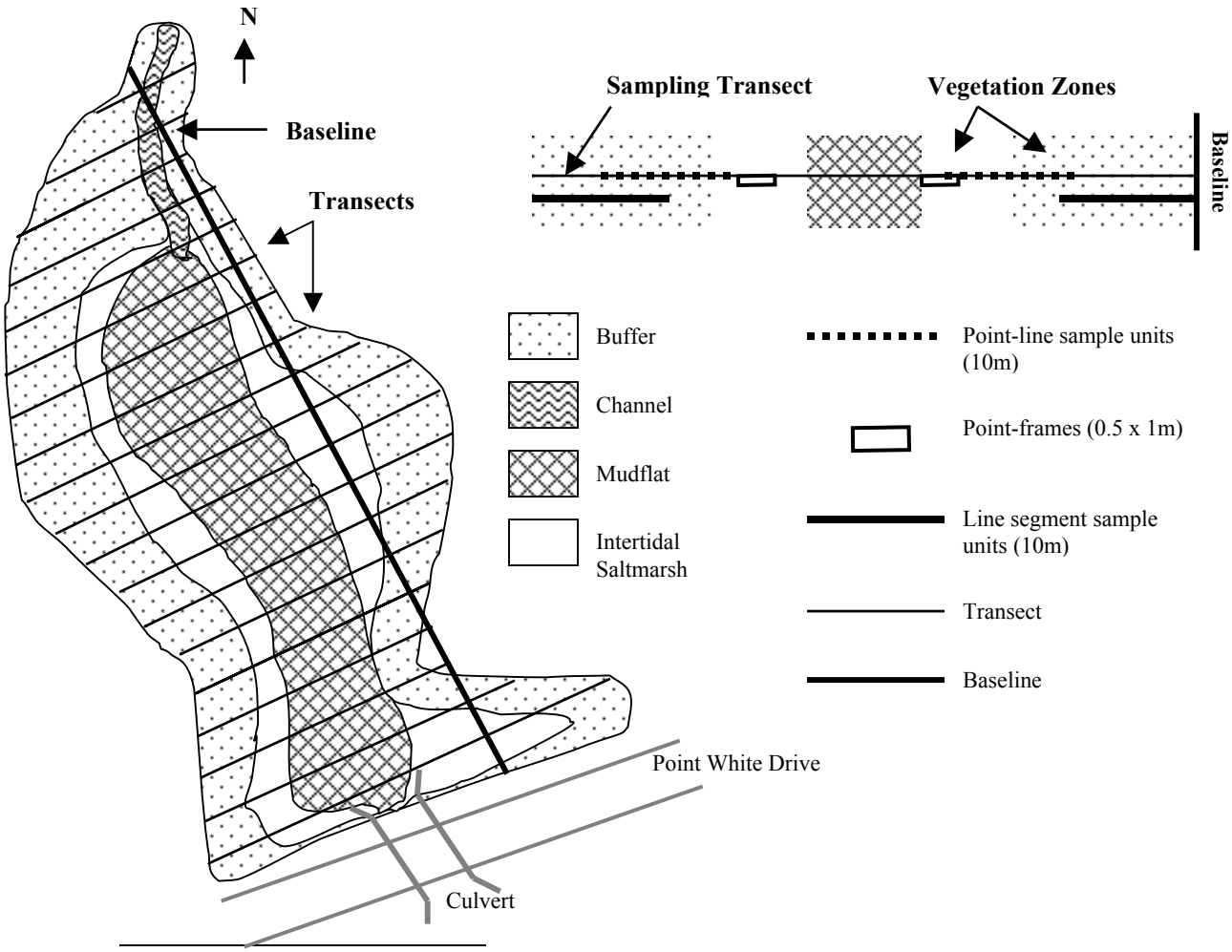
In February 2002, a hand refractometer was used to measure salinity in the estuary at high tide. Salinity readings were recorded in parts per thousand (ppt).

Vegetation monitoring was conducted in August 2001. A temporary 120-meter baseline was placed along the eastern edge of the mitigation site. Twenty-four temporary sampling transects were placed perpendicular to the baseline using a systematic random sampling

method (Fig. 1). Intertidal saltmarsh and upland buffer zones were identified along each transect using a combination of topographic and vegetation cues. Both herbaceous and woody species cover data were collected along each transect. No sampling was conducted in the mudflat.

For native emergent plant communities, the point frame method (Bonham 1989; Elzinga et al. 1998) was used to collect aerial cover data.[8] Ninety-one point frame sample unit locations were identified along transects in the intertidal saltmarsh using a simple random sampling method (Fig. 1). At data collection points in each frame, a pin flag was lowered from above the tallest vegetation. All plant species intercepted by the pin flag were recorded. If the pin intercepted no plant species, the ground surface was recorded as bare soil, moss, or habitat structure.[9]

Figure 1 Schel-chélb Vegetation Sampling Design Sketch (August 2001).



[8] The Wetland Monitoring Program typically uses a frame formed with polyvinyl chloride (PVC). Strings span the frame lengthwise and points are marked on the strings using a standard randomization method.
[9] Aerial cover calculations include only areas covered by vascular plants (including floating-leaved species). For compliance purposes, areas covered by thallophytes, bryophytes, structures, or aquatic vegetation are not included in the calculations. Scientific names, common names, hydrophytic plant indicator status, and nativity used in this report were obtained from the PLANTS Database (USDA 2001).

Aerial cover data for the woody species plant community were collected using the line intercept method (Canfield 1941; Bonham 1989). Sixty-two sample units (10m lines) were placed along transects in the upland buffer using a systematic random sampling method (Fig.1). All woody vegetation intercepting a tape measure stretched the length of each sampling unit was identified and the length of the canopy intercept was recorded.

To assess cover of undesirable (invasive) species, the point-line method (Bonham 1989; Coulloudon 1999) was used to collect aerial cover data. Following a random start, ninety-six 10-meter point line sample units were placed along transects in the upland buffer and intertidal saltmarsh zones using a systematic random sampling method (Fig. 1). At each data collection point, a vertical rod tipped with a pin or pin flag was lowered from above the tallest vegetation. Plant species intercepted by the pin were recorded.

Table 1 provides details of the point frame, line intercept, and point-line sampling methods employed at the estuary in 2001.

Performance Standard	Monitoring Method	Randomization Method	Sample Unit Dimensions	Units	Resolution
Emergent species cover	Point frame	Simple	1m × 0.5m	91	30 points/unit
Woody species cover	Line intercept	Systematic	10m lines	62	0.1m gap rule[10]
Invasive species cover	Point-line	Systematic	10m point-line	96	40 points/unit

Table 1 Vegetation Sampling Design Summary

Sample size analysis was conducted to determine if sufficient sampling had been completed to achieve the sampling objectives. The following equation was used to perform this analysis.

$$n = \frac{(z)^2 (s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[11]
n = unadjusted sample size

A sample size correction to n is necessary to adjust "point-in-time" parameter estimates.[12] The adjusted n value reveals the number of sample units required to report the estimated mean value at a specified level of confidence.

Using the point count method (Ralph et al. 1993), five 10-minute bird surveys were conducted at the Schel-chélb estuary and Harper reference site between April and July 2001. Values for species richness and relative abundance were recorded.

[10] Woody plants with canopy gaps less than 0.1m were considered continuous with no break in cover.
[11] In this equation, the precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.
[12] Adjusted n values were obtained using the algorithm for a one-sample tolerance probability of 0.90 (Kupper and Hafner 1989; Elzinga et al. 1998).

Species diversity indices (H) were calculated for each of the five data sets using the Shannon-Wiener function (Krebs 1999). A mean annual species diversity index was calculated for each site.

$$H' = -\sum_{i=1}^{s} (p_i)(\log p_i)$$

H' = index of species diversity
s = number of species
p_i = proportion of sample belonging to ith species

The following *t* test was used to test the null hypothesis that diversity indices from the Harper reference site and the Schel-chélb estuary are equal (Zar 1999).

$$t = \frac{H'_1 - H'_2}{S_{H'_1 - H'_2}}$$

H' = index of species diversity
$S_{H'_1 - H'_2}$ = standard error of the difference between species diversity indices H'_1 and H'_2

Aquatic macroinvertebrate samples were collected from four locations across the estuary. The sampling protocol was designed to measure invertebrate prey resources important to juvenile salmonids and provide a community level analysis that is comparable to the reference site. Benthic macroinvertebrates in the intertidal flat were sampled from cores taken with a standard tube sampler (clam gun) (Swanson 1978; Brooks and Hughes 1988). Samples were rinsed and filtered through a 0.5mm sieve, then placed in a sample jar and preserved in alcohol for later analysis (McCafferty and Provonsha 1998).

Invertebrates were identified using a technical key (Plotnikoff and White 1996). Taxa known to be important to juvenile salmonids and indicators of pollution intolerance (e.g., *Polychaeta*, *Mollusca*, and *Crustacea*) were identified to at least the family level. Following identification, all invertebrate samples were archived for future reference.

Incidental wildlife observations were recorded during all site visits.

Results and Discussion

Results from the topographic survey conducted in February 2002 show the area of tidal inundation at the Schel-chélb estuary is 2.27 acres with an average slope of 13:1 (horizontal to vertical) (h:v). These results compare favorably to performance standards that require 2.0 acres of tidal inundation and an average slope flatter than 7:1 (h:v) (Objectives 1 and 4).

The open culvert that runs beneath Baker Road rises from an elevation of 11.363 feet at the east end to 11.559 feet on the west. Though fish passage is possible at tidal elevations greater than +11.559 feet MLLW, these findings indicate the fifth year performance standard has not been achieved. The standard requires an open culvert with 0% slope and an invert elevation of +11.0 feet (Objective 5).

Soils analysis shows the composite soil sample collected from the Schel-chélb estuary contains 15.6% silt and 2.1% clay sized particles, for a total 17.7%. In 1998, a similar

sample contained 9.0% silt and 2.4% clay sized particles, for a total 11.4%. Using the Unified Soil Classification System Guidelines (ASTM 2001), the soil sample collected in 1998 classifies as sand with silt while the sample from 2002 is silty sand. These results indicate soils in the tide flat have achieved performance standards that require a change from sand to silty sand (Objectives 1 and 4).

A salinity reading of 20 ppt was recorded at high tide in the Schel-chélb estuary. This value compares to marine salinity readings from 30 to 35 ppt, and readings from Eagle Harbor in Puget Sound that range from 27.5-28.5 ppt. These findings indicate a mixohaline environment exists in the estuary as expected (Objective 1 and 4).

Data analysis shows the intertidal saltmarsh provides an estimated 73% (CI 0.90 ± 0.10) aerial cover of native saltmarsh plants (Fig. 2). This compares to the standard that requires 75% aerial vegetative cover in Year 5 (2001) (Objective 2). As intended, records indicate a mix of fresh and saltwater tolerant species. *Schoenoplectus maritimus* (cosmopolitan bulrush) and *Distichlis spicata* (seashore saltgrass) dominate the estuary's high and low saltmarsh plant communities, respectively. Other species include *Agrostis exarata* (spike bentgrass), *Atriplex patula* (spear salt bush) *Deschampsia caespitosa* (tufted hairgrass), *Juncus articulatus* (jointed rush), *Juncus ensifolius* (dagger-leaf rush), *Plantago maritima* (seaside plantain), *Salicornia virginica* (Virginia glasswort), and *Triglochin maritimum* (seaside arrow-grass). Appendix C provides a complete list of plant species identified at the Schel-chélb estuary in 2001.

Figure 2 **Saltmarsh Plant Community** (August 2001)

Figure 3 **Woody Species Plant Community** (August 2001)

An aerial cover estimate of 56% (CI 0.90 ± 0.13) was calculated for tree and shrub species in the upland buffer (Fig 3). This compares favorably to the standard that requires 50% aerial cover of woody species in Year 5 (Objective 2). *Alnus rubra* (red alder) and *Salix sitchensis* (Sitka willow) dominate the woody canopy and have colonized large areas along the north and eastern edge of the mitigation site (Fig. 3). Other native species include *Cornus sericea* (red-stemmed dogwood), *Crataegus douglasii* (black hawthorne), *Malus fusca* (Oregon crabapple), *Rosa nutkana* (Nootka rose), *Rosa pisocarpa* (peafruit rose), *Rubus spectabilis* (salmonberry), and *Symphoricarpos albus* (common snowberry).

The monitoring record shows an aerial cover estimate of 5% (CI 0.80 ± 0.27) was calculated for invasive species in the intertidal saltmarsh and upland zones of the Schel-chélb estuary. This estimate falls below the 10% threshold specified in the Year 5 Performance Standard (Objective 2). An aggressive weed control program implemented by local residents and WSDOT work crews may be largely responsible for this positive result. *Spartina* (cordgrass) species have not been found on the mitigation site.

Bird surveys were conducted at the Schel-chélb and Harper sites from April through July 2001. Eight wetland-dependent species including several shorebird, waterfowl, and passerine species were recorded during bird surveys conducted at the Schel-chélb estuary. By comparison, five wetland-dependent species were recorded at the Harper reference site. In addition, while no upland birds were present during bird surveys at the Harper site, three were recorded in the upland buffer at Schel-chélb.

Though records show similar types of birds are present at both sites, values for species and family richness are higher for the Schel-chélb mitigation site. Avian species diversity indices calculated for both sites show a statistically significant difference ($P = 0.002$), with higher values recorded for the Schel-chélb estuary (Table 2). These results indicate performance standards for bird species richness and species diversity have been achieved in Year 5 (Objective 3).

Attribute	Schel-chélb Estuary	Harper Reference Site
Species Richness	38 species	25 species
Family Richness	20 avian families	16 avian families
Species Diversity Index		
Mean	1.157	0.991
Standard error	0.013	0.010
Range	1.050-1.229	0.911-1.050

Table 2 **Bird Survey Results** (April – July 2001)

Habitat complexity may account for differences observed in bird species richness and species diversity at the Schel-chélb and Harper estuaries (Milligan 1985; Finch 1989; Johnson and O'Neil 2001). While emergent, scrub-shrub, and upland habitats are present at the Schel-chélb mitigation site, well developed scrub-shrub and wetland buffer zones are largely absent from the Harper reference site.

Appendices B and C list species recorded during formal bird surveys at the Harper reference site and Schel-chélb estuary from April through July 2001.

Benthic macroinvertebrate samples were collected from four locations across the Schel-chélb estuary in September 2001. Invertebrates from these collections were identified to the family level. Seventeen invertebrate families were present in the samples collected. This value exceeds the performance standard that requires benthic invertebrate family richness values of at least 25 percent the number at the Harper reference site in Year 2 (1998) (Objective 4). Only 13 invertebrate families were identified from samples collected at the Harper estuary in 1998.

Individuals from taxa known to be important to juvenile salmonids and indicators of pollution intolerance were identified in samples collected from the Schel-chélb estuary. These include families from the *Mollusca*, *Coleoptera*, *Megaloptera*, *Plecoptera*, and *Trichoptera* invertebrate orders.

Appendices B and E provide a summary of benthic macroinveretebrate sampling results for the Harper reference site and Schel-chélb estuary.

Summary

The following table summarizes monitoring results from wildlife, vegetation, soil, topography, and water quality surveys conducted at the Schel-chélb estuary in 2001 and 2002. Year 5 (2001) performance standards are addressed in this table.

Table 3

Performance Standard	2001 Monitoring Results	Standards Achieved
A topographic survey shows a tidally inundated estuary of 2.0 acres or greater.	Area of tidal inundation is 2.27 acres.	Yes
Soil texture shows a change from sand to silty sand substrate.	11.4% (1998) to 17.7% (2001) silt and clay sized particles.	Yes
Salinity readings indicate a mixohaline environment.	20 parts per thousand.	Yes
Tide heights and periods similar to NOAA predicted heights.	Full, unimpeded tidal exchange between the estuary and Puget Sound.	Yes
Cover of native plants is at least 75% in the intertidal saltmarsh.	73% (CI 0.90 ± 0.10) [13]	Yes
Cover of native trees and shrubs is at least 50% in the upland buffer.	56% (CI 0.90 ± 0.13)	Yes
Cover of undesirable species including cord grass is less than 10%.	5% (CI 0.80 ± 0.27)	Yes
Numbers, species, and types of birds will be similar to those observed at the Harper reference site.	Avian species richness and diversity indices ($P = 0.002$) are greater at the Schel-chélb estuary.	Yes
Number of bird species using the adjacent upland habitats will be at least two-thirds the number at Harper.	Three upland bird species recorded at Schel-chélb. Harper records show no upland birds.	Yes
Survey results show a tidally inundated estuary with average slopes flatter than 7:1 (h:v)	Area of tidal inundation has a slope of 13:1 (h:v).	Yes
Benthic invertebrate family richness is at least 25% the number at Harper.	17 families present at the Schel-chélb estuary; 13 families at Harper (1998).	Yes
The culvert under Baker Road shall be open and provide fish passage at tidal elevations greater than +11.5 feet MLLW.	The open culvert rises from an elevation of 11.363 to 11.559 feet.	No

[13] We are 90% confident that the true aerial cover value for native saltmarsh plants is between 68.6% and 77.4%. The performance standard of 75% lies within the confidence interval range.

Appendix A
Plant Community Development at the Schel-chélb Estuary

Introduction

The *Operations, Maintenance, and Monitoring Plan (OMMP) for the West Harbor Operable Unit Wykoff/Eagle Harbor Superfund Site* (Hart Crowser 1997) details the Washington State Department of Transportation's (WSDOT) responsibilities for construction, maintenance, and monitoring of the Schel-chélb estuary mitigation site. Following an agreement with the Environmental Protection Agency (EPA), the OMMP was amended in 1999 to reflect changes in the planting schedule for the mitigation site. These changes are documented in the *Eagle Harbor Operations, Maintenance, and Monitoring Plan Update* (WSDOT 1999).

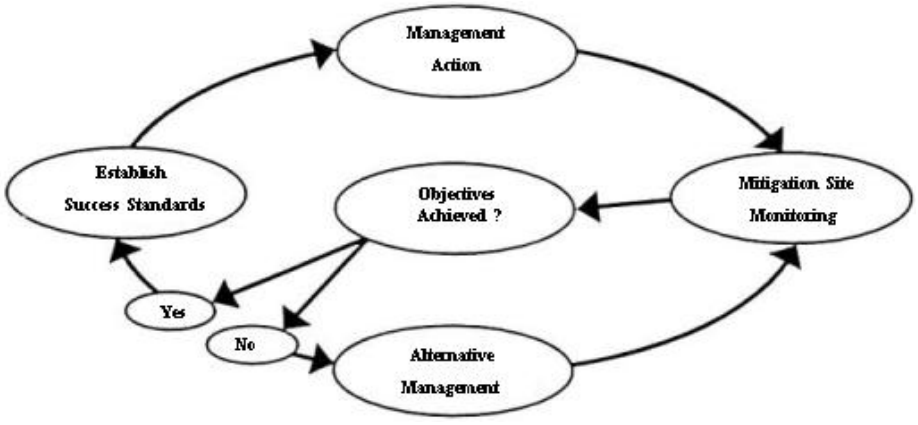
The Schel-chélb mitigation site is located on the site of a historical estuary that was filled as roads were constructed at the turn of the last century. During construction of the Schel-chélb estuary, opportunities arose to stockpile and replace existing topsoil. This topsoil had many dormant plant propagules that emerged shortly after mitigation site construction was complete. Rapid colonization of the mitigation site occurred. As a result, representatives from EPA and WSDOT agreed to implement a managed succession approach to revegetation of the Schel-chélb estuary.

Adaptive Management

Active management may not be required if the Schel-chélb mitigation site is progressing toward its intended goals, objectives, and performance standards. When this is not the case, a mid-course correction may be necessary. Managed succession coupled with WSDOT's adaptive management plan provide a flexible and effective management strategy that helps ensure mitigation site success.

WSDOT's adaptive management plan follows the model illustrated in Figure A-1 (Elzinga et al. 1998). In this process: (1) performance standards are developed to describe some desired condition; (2) management activities are implemented to achieve the

Fig. A-1 **The Adaptive Management Cycle** (Redrawn from Elzinga et al. 1998).



desired performance standards; (3) the response of the resource is monitored to determine if performance standards have been met; and (4) management is adapted or changed if performance standards are not achieved. Monitoring is a critical component of the adaptive management process, providing the link between performance standards and site management activities.

The following describes the status of vegetative community development at the Schel-chélb estuary. The discussion includes comparisons to the original planting plan.

Site Objectives
The primary goal of the Schel-chélb mitigation effort is to restore the historical intertidal estuary. A self-sustaining, functional wetland system with intertidal flat, saltmarsh, and scrub-shrub habitats is the intended result. A full text of the goals, objectives, and performance standards for this site are included in the *Schel-chélb Estuary Site Wetland Construction/Restoration Plan* (Swanson et al. 1998) and on pages 5 through 9 of this report.

The original planting plan specifies three distinct zones of vegetation including an upland buffer with trees and shrubs, a riparian area dominated by shrubs, and a tidally influenced emergent wetland. Each of these zones is further divided based on anticipated soil conditions, hydrology, and aspect.

Comparison Results
Data analysis shows the scrub-shrub and emergent wetland plant communities intended for the estuary are well established. Species diversity and habitat complexity have increased as native woody and herbaceous plants continue to colonize areas of the mudflat, saltmarsh, riparian zone, and upland buffer.

Only two shrub species included in the original planting plan are not present on the mitigation site. These species are *Salix hookeriana* (Hooker willow) and *Salix scouleriana* (Scouler willow). Many native species absent from the original planting plan have colonized the site. These species include *Fraxinus latifolia* (Oregon ash), *Alnus rubra* (red alder), *Crataegus douglasii* (black hawthorne), *Populus balsamifera* (black cottonwood), *Rubus spectabilis* (salmonberry), *Salix sitchensis* (Sitka willow), and *Symphoricarpos albus* (common snowberry).

In the emergent plant community, native sedge and rush species have colonized large areas of the intertidal flat and saltmarsh. Species include *Carex lyngbyei* (Lyngby's sedge), *Carex stipata* (owlfruit sedge), *Carex unilateralis* (lateral sedge), *Juncus acuminatus* (tapertip rush), *Juncus articulatus* (jointed rush), *Juncus bufonius* (toad rush), *Juncus effuses* (common rush), *Juncus ensifolius* (sword leaf rush), *Juncus gerardii* (saltmeadow rush), *Juncus tenuis* (slender rush), and *Schoenoplectus maritimus* (cosmopolitan bulrush). These species were not included in the original planting plan.

Table A-1 provides a list of native plants recorded during monitoring visits to the estuary in August 2001. Comparisons are made to the original planting plan.

Scientific Name	Common Name	Present in the Planting Plan	Present on Site in 2001
Agrostis exarata	spike bentgrass		X
Alnus rubra	red alder		X
Arbutus menziesii	Pacific madrone	X	X
Argentina anserina	silverweed cinquefoil	X	X
Atriplex patula	spear salt bush	X	X
Carex lyngbyei	Lyngby's sedge		X
Carex stipata	owlfruit sedge		X
Carex unilateralis	lateral sedge		X
Cornus sericea	redosier dogwood	X	X
Crataegus douglasii	black hawthorne		X
Deschampsia caespitosa	tufted hairgrass	X	X
Distichlis spicata	inland saltgrass	X	X
Eleocharis palustris	common spikerush		X
Festuca rubra	red fescue		X
Fraxinus latifolia	Oregon ash		X
Juncus acuminatus	tapertip rush		X
Juncus articulatus	jointed rush		X
Juncus bufonius	toad rush		X
Juncus effusus	common rush		X
Juncus ensifolius	sword leaf rush		X
Juncus gerardii	saltmeadow rush		X
Juncus tenuis	slender rush		X
Leymus mollis	American dunegrass		X
Malus fusca	Oregon crabapple	X	X
Mimulus dentatus	costal monkeyflower		X
Mimulus guttatus	seep monkey-flower		X
Plantago major	common plantain		X
Plantago maritima	goose tongue		X
Populus balsamifera	black cottonwood		X
Puccinellia pumila	dwarf alkaligrass		X
Rosa nutkana	Nootka rose	X	X
Rosa pisocarpa	cluster rose	X	X
Rubus spectabilis	salmonberry		X
Rubus ursinus	California blackberry		X
Salicornia virginica	Virginia glasswort	X	X
Salix lucida	Pacific willow	X	X
Salix sitchensis	Sitka willow		X
Sambucus racemosa	red elderberry	X	
Schoenoplectus maritimus	cosmopolitan bulrush		X
Spergularia marina	salt sandspurry		X
Stachys mexicana	Mexican hedgenettle		X
Symphoricarpos albus	common snowberry		X
Triglochin maritimum	seaside arrow-grass	X	X
Typha latifolia	broadleaf cattail		X
Veronica americana	American speedwell		X

Table A-1 Native species recorded at the Schel-chélb site in August 2001. Many species not included in the original planting plan are well established.

Figure A-2 represents the vegetation communities present at the Schel-chélb estuary in August 2001. Data records and site observations show plant communities in the intertidal saltmarsh and upland buffer are developing as intended.

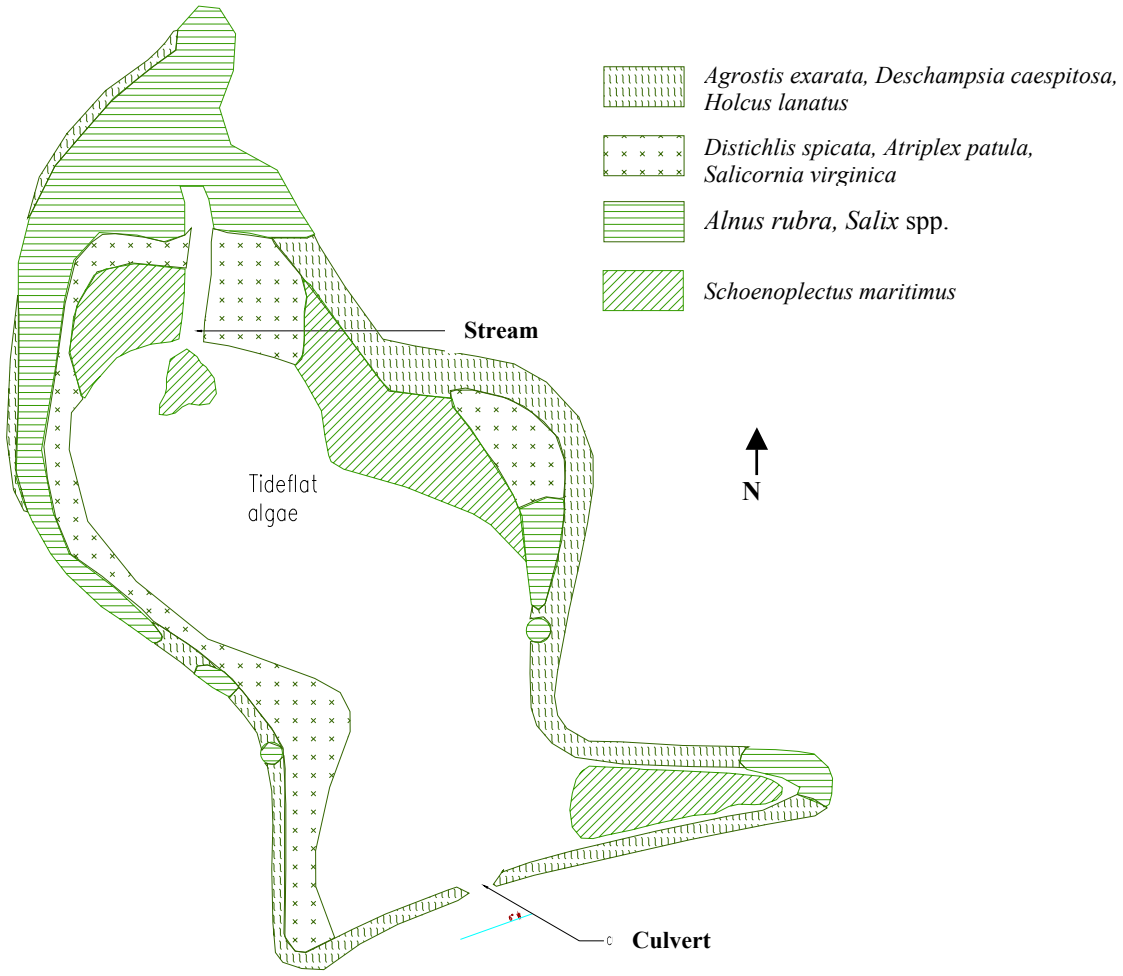


Fig. A-2 **Plant Communities at the Schel-chélb Estuary** (August 2001)

Management Activities

Management activities include control of undesirable (invasive) species, supplemental plantings, and use of other corrective measures to ensure mitigation site success. *Cytisus scoparious* (Scotch broom) and *Cirsium spp.* (thistles) were removed from the estuary during site visits in July 2001 and March 2002. As the mitigation site matures, *Thuja plicata* (red cedar) may be planted under the *Alnus rubra* (red alder) canopy. Supplemental plantings are intended to add diversity to the upland plant community.

Appendix B
Harper Reference Site

Data collected at the Harper reference site provides baseline information to measure progress of the Schel-chélb mitigation site in the fifth and tenth years of monitoring. The following summarizes monitoring methods and results for the Harper reference site.

Monitoring and Sampling Objectives

Monitoring Objective 1
Assess aerial vegetative cover of native saltmarsh plants in the intertidal saltmarsh.

> Sampling Objective 1
> To be 80% confident the mean aerial cover estimate for native saltmarsh plants is within 20% of the true value.

Monitoring Objective 2
Assess aerial cover of undesirable (invasive) species for the entire site.

> Sampling Objective 2
> To be 80% confident the mean aerial cover estimate for invasive species is within 20% of the true value.

Monitoring Objective 3
Assess aerial vegetative cover of native trees and shrubs in the upland buffer.

Methods
To assess vegetative attributes on site, a baseline was established east to west across the intertidal saltmarsh. Twenty sampling transects were located perpendicular to the baseline using a systematic random sampling method (Fig. B-1).

For the native emergent plant community, the point frame method (Bonham 1989; Elzinga et al. 1998) was used to collect aerial cover data. One hundred fifty-nine point frame locations were identified along sampling transects using a systematic random sampling method (Fig. B-1). Each frame (0.5m × 1m) contained 30 data collection points.

To assess cover of undesirable (invasive) species, the point-line method (Bonham 1989; Coulloudon 1999) was used to collect aerial cover data. Following a random start, eighty-five 10-meter point-line sample units (40 points/line) were placed along transects across the site using a systematic random sampling method (Fig. B-1).

For both point frame and point-line sample units, a pin flag was lowered from above the tallest vegetation at each data collection point. Plant species intercepted by the pin were recorded.

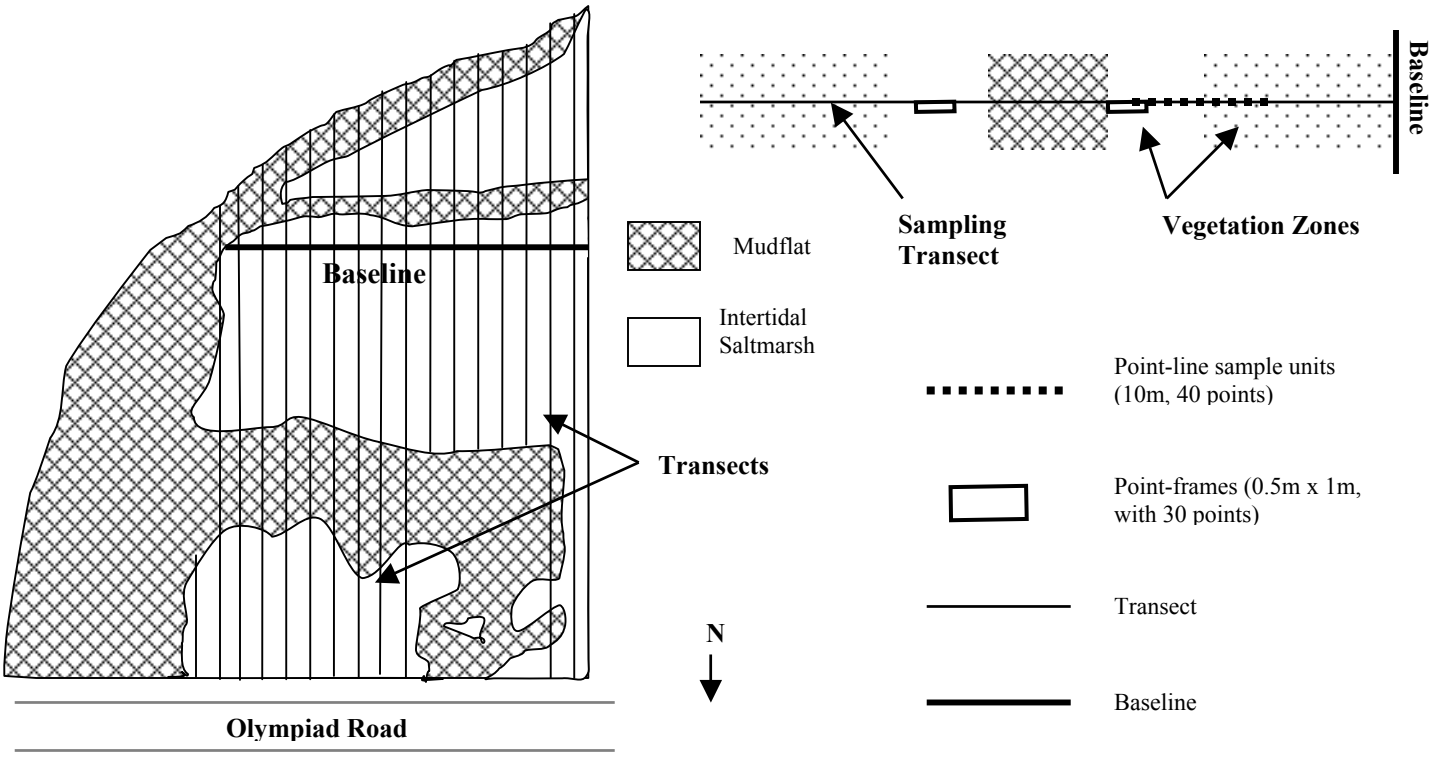


Figure B-1 **Harper Vegetation Sampling Design Sketch** (August 2001)

Sample size analysis was conducted to determine if sufficient sampling had been completed to achieve the sampling objectives. The following equation was used to perform this analysis (Elzinga et al. 1998).

$$n = \frac{(z)^2(s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[14]
n = unadjusted sample size

A sample size correction to n is necessary to adjust "point-in-time" parameter estimates.[15] The adjusted n value reveals the number of sample units required to report the estimated mean value at a specified level of confidence.

A narrow zone of scrub-shrub vegetation surrounds the Harper reference site. Small size and patchy distribution make it difficult to assess cover in this zone quantitatively. Cover of native trees and shrubs in the upland zone was assessed qualitatively in 2001.

Using the point count method (Ralph et al. 1993), five 10-minute bird surveys were conducted at the Harper reference site from April through July 2001. Values for species richness and relative abundance were calculated.

[14] In this equation, the precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.
[15] Adjusted n values were obtained using the algorithm for a one-sample tolerance probability of 0.90 (Kupper and Hafner 1989; Elzinga et al. 1998).

Species diversity indices (H) were calculated for each of the five data sets using the Shannon-Wiener function (Krebs 1999). A mean annual species diversity index was calculated for the site.

$$H' = -\sum_{i=1}^{s} (p_i)(\log p_i)$$

H' = index of species diversity
s = number of species
p_i = proportion of sample belonging to ith species

The following *t* test was used to test the null hypothesis that diversity indices from the Harper reference site and the Schel-chélb estuary are equal (Zar 1999).

$$t = \frac{H_1' - H_2'}{S_{H_1' - H_2'}}$$

H' = index of species diversity
$S_{H_1' - H_2'}$ = standard error of the difference between species diversity indices H_1' and H_2'

Aquatic macroinvertebrate samples were collected from four locations across the estuary in 1998. The sampling protocol was designed to measure invertebrate prey resources important to juvenile salmonids and provide a community level analysis that is comparable to the mitigation site. Benthic macroinvertebrates in the intertidal flat were sampled from cores taken with a standard tube sampler (clam gun) (Swanson 1978; Brooks and Hughes 1988). Invertebrate samples were rinsed and filtered through a 0.5mm sieve, then placed in a sample jar and preserved in alcohol for later analysis (McCafferty and Provonsha 1998).

Invertebrates were identified using a technical key (Plotnikoff and White 1996). Taxa known to be important to juvenile salmonids and indicators of pollution intolerance (e.g., *Polychaeta*, *Mollusca*, and *Crustacea*) intolerance were taken to at least the family level. Following identification, all invertebrate samples were archived for future reference.

Incidental wildlife observations were recorded during all site visits.

Results

Analysis of point-frame data shows cover of native saltmarsh species in the intertidal zone is estimated to be 99% (CI 0.99 ± 0.01). *Distichlis spicata* (inland saltgrass), *Salicornia virginica* (Virginia glasswort), and *Juncus gerardii* (saltmeadow rush) dominate this zone.

Low cover and a patchy plant distribution made quantitative estimates of undesirable (invasive) species and scrub-shrub cover impracticable. An ocular estimate of less than 10% was recorded for undesirable (invasive) species cover in the scrub-shrub and intertidal saltmarsh zones. The narrow upland buffer that surrounds the reference site provides less than 10% scrub-shrub cover.

Table B-1 lists plant species identified during monitoring visits to the Harper reference site in August 2001.

Scientific Name[16]	Common Name	Status	Nativity
Acer macrophyllum	bigleaf maple	FACU	Native
Agrostis capillaris	colonial bentgrass	FAC	Non Native
Agrostis exarata	spike bentgrass	FACW	Native
Agrostis gigantea	redtop	FACW	Non Native
Alnus rubra	red alder	FAC	Native
Argentina anserina	silverweed cinquefoil	OBL	Native
Atriplex patula	spear salt bush	FACW	Native
Carex lyngbyei	Lyngby's sedge	OBL	Native
Cirsium vulgare	bull thistle	FACU	Non Native
Convolvulus arvensis	field bindweed	NL	Non Native
Cuscuta salina	saltmarsh dodder	NL	Native
Cytisus scoparius	Scotch broom	UPL	Non Native
Deschampsia caespitosa	tufted hairgrass	FACW	Native
Distichlis spicata	inland saltgrass	FACW	Native
Elymus repens	quackgrass	FACU	Non Native
Festuca rubra	red fescue	FAC	Native
Grindelia integrifolia	Puget Sound gumweed	FACW	Native
Hedera helix	English ivy	NL	Non Native
Holcus lanatus	common velvetgrass	FAC	Non Native
Hordeum brachyantherum	meadow barley	FACW	Native
Hordeum jubatum	foxtail barley	FAC+	Native
Hypochaeris radicata	hairy catsear	NL	Non Native
Jaumea carnosa	marsh jaumea	OBL	Native
Juncus gerardii	saltmeadow rush	FACW+	Native
Lathyrus sylvestris	flat pea	NL	Non Native
Plantago lanceolata	narrowleaf plantain	FACU+	Non Native
Plantago maritima	goose tongue	FACW+	Native
Polygonum aviculare	prostrate knotweed	FACW-	Non Native
Polygonum cuspidatum	Japanese knotweed	NL	Non Native
Pseudotsuga menziesii	Douglas-fir	NL	Native
Rosa nutkana	Nootka rose	NL	Native
Rubus armeniacus	Himalayan blackberry	FACU-	Non Native
Rubus laciniatus	cutleaf blackberry	FACU+	Non Native
Rubus spectabilis	salmonberry	FAC	Native
Salicornia virginica	Virginia glasswort	OBL	Native
Spergularia canadensis	Canada sandspurry	FACW	Native
Thuja plicata	western red cedar	FAC	Native
Triglochin maritimum	seaside arrow-grass	OBL	Native

Table B-1 Harper Reference Site Plant List (August 2001)

Twenty-five bird species from 16 avian families were present during surveys at the Harper reference site from April through July 2001. Table B-2 lists species recorded during surveys last year. Birds are assigned an upland or wetland-dependent species status based on the classification scheme presented in Brown and Smith (1998). Regional variation occurs. Additional references used to further classify bird species include Thomas (1979), Ehrlich et al. (1988), and Smith et al. (1997).

[16] Scientific names, common names, hydrophytic plant indicator status, and nativity used in this report were obtained from the PLANTS Database (USDA 2001).

Family Name[17]	Common Name	Scientific Name	Status
Ardeidae	Great Blue Heron	*Ardea herodias*	wetland-dependent
	Mallard	*Anas platyrhynchos*	wetland-dependent
	Green-winged Teal	*Anas crecca*	wetland-dependent
Charadriidae	Killdeer	*Charadrius vociferus*	
Laridae	Glaucous-winged Gull	*Larus glaucescens*	
Alcedinidae	Belted Kingfisher	*Ceryle alcyon*	wetland-dependent
Tyrannidae	Pacific-slope Flycatcher	*Empidonax difficilis*	
Hirundinidae	Violet-green Swallow	*Tachycineta thalassina*	
	Barn Swallow	*Hirundo rustica*	
Corvidae	Northwestern Crow	*Corvus* caurinus	
Paridae	Black-capped Chickadee	*Parus atricapillus*	
	Chestnut-backed Chickadee	*Parus rufescens*	
Troglodytidae	Bewick's Wren	*Thryomanes bewickii*	
Sylviidae	Ruby-crowned Kinglet	*Regulus calendula*	
Turdidae	Swainson's Thrush	*Catharus ustulatus*	
	American Robin	*Turdus migratorius*	
Bombycillidae	Cedar Waxwing	*Bombycilla cedrorum*	
Sturnidae	European Starling	*Sturnus vulgaris*	
Emberizidae	Orange-crowned Warbler	*Vermivora celata*	
	Wilson's Warbler	*Wilsonia pusilla*	
	Spotted Towhee	*Pipilo maculatus*	
	Song Sparrow	*Melospiza melodia*	
Icteridae	Red-winged Blackbird	*Agelaius phoeniceus*	wetland-dependent
Fringillidae	House Finch	*Carpodacus mexicanus*	
	Pine Siskin	*Carduelis pinus*	

Table B-2 Harper Reference Site Bird Survey List (April – July 2001)

Thirteen benthic macroinvertebrate families were identified from samples collected at the Harper reference site in 1998 (Table B-3).

Table B-3 Benthic Macroinvertebrate Summary for the Harper Estuary (August 1998)

Order	Family	Common Name	Abundance	Relative Percent
Amphipoda	*Coriphiidae*	scud	304	46.4
Coleoptera	*Elmidae*	water beetles	16	2.4
Cumacea	*Leuconiidae*	crustacean	14	2.1
Diptera	*Ceratopogonidae*	aquatic flies	102	15.5
	Chironomidae	aquatic flies	1	0.2
	Dolichopodidae	aquatic flies	3	0.5
	Ephydridae	aquatic flies	1	0.2
Homoptera	*Cercopidae*	Water strider	1	0.2

[17] The Harper bird species list follows the American Ornithologists' Union Checklist of North American Birds (AOU 1998). The list incorporates changes made in the 42nd Supplement to the Checklist, as published in the Auk 117:847-858, 2000.

Order	Family	Common Name	Abundance	Relative Percent
Oligochaeta	*Enchytraeidae*	segmented worms	1	0.2
Polycheta	*Capitellidae*	segmented worms	164	25.0
	Phyllodocidae	segmented worms	1	0.2
	Spionidae	segmented worms	42	6.3
Tanaidacea	*Tanaidae*	crustacean	5	0.8
Total			**655**	**100%**

Appendix C
Schel-chélb Estuary Plant List (August 2001)

Scientific Name[18]	Common Name	Status	Nativity
Agrostis capillaris	colonial bentgrass	FAC	Non Native
Agrostis exarata	spike bentgrass	FACW	Native
Alnus rubra	red alder	FAC	Native
Argentina anserina	silverweed cinquefoil	OBL	Native
Asteraceae	aster family (composites)		
Atriplex patula	spear salt bush	FACW	Native
Carex lyngbyei	Lyngby's sedge	OBL	Native
Cirsium arvense	Canada thistle	FACU+	Non Native
Cornus sericea	redosier dogwood	NL	Native
Crataegus douglasii	black hawthorne	FAC	Native
Cytisus scoparius	Scotch broom	UPL	Non Native
Dactylis glomerata	Orchard grass	FACU	Non Native
Daucus carota	Queen Anne's lace	NL	Non Native
Deschampsia caespitosa	tufted hairgrass	FACW	Native
Distichlis spicata	inland saltgrass	FACW	Native
Eleocharis palustris	common spikerush	OBL	Native
Eleocharis parvula	dwarf spikerush	OBL	Non Native
Festuca rubra	red fescue	FAC	Native
Fraxinus latifolia	Oregon ash	FACW	Native
Holcus lanatus	common velvetgrass	FAC	Non Native
Juncus acuminatus	Tapertip rush	OBL	Native
Juncus articulatus	jointed rush	OBL	Native
Juncus bufonius	toad rush	FACW+	Native
Juncus ensifolius	swordleaf rush	FACW	Native
Juncus gerardii	saltmeadow rush	FACW+	Native
Leymus mollis	American dunegrass	NL	Native
Malus fusca	Oregon crabapple	FAC+	Native
Plantago major	common plantain	FAC+	Native
Plantago maritima	goose tongue	FACW+	Native
Poaceae	grass family		
Populus balsamifera	black cottonwood		Native
Prunus sp.	plum, cherry		
Puccinellia pumila	dwarf alkaligrass	NA	Native
Rosa nutkana	Nootka rose	NI	Native
Rosa pisocarpa	cluster rose	FACU	Native
Rosa sp.	Rose		
Rubus armeniacus	Himalayan blackberry	FACU-	Non Native
Rubus laciniatus	cutleaf blackberry	FACU+	Non Native

[18] Scientific names, common names, hydrophytic plant indicator status, and nativity used in this report were obtained from the PLANTS Database (USDA 2001).

Scientific Name	Common Name	Status	Origin
Rubus spectabilis	salmonberry	FAC	Native
Rubus ursinus	California blackberry	NL	Native
Salicornia virginica	Virginia glasswort	OBL	Native
Salix lucida	Pacific willow	FACW+	Native
Salix sitchensis	Sitka willow	FACW	Native
Schoenoplectus maritimus	cosmopolitan bulrush	OBL	Native
Spergularia marina	salt sandspurry	OBL	Native
Symphoricarpos albus	common snowberry	FACU	Native
Trifolium hybridum	alsike clover	FACU+	Non Native
Trifolium pratense	red clover	FACU	Non Native
Trifolium repens	white clover	FACU+	Non Native
Trifolium sp.	Clover		
Triglochin maritimum	Seaside arrow-grass	OBL	Native
Veronica sp.	speedwells		

Appendix D
Schel-chélb Bird Survey List (2001)

The following list includes species recorded during surveys from April through July 2001. Birds are assigned an upland or wetland-dependent species status based on the classification scheme presented in Brown and Smith (1998). Regional variation occurs. Additional references used to further classify bird species include Thomas (1979), Ehrlich et al. (1988), and Smith et al. (1997).

Family Name[19]	Common Name	Scientific Name	Status
Ardeidae	Great Blue Heron	*Ardea herodias*	wetland-dependent
	Canada Goose	*Branta canadensis*	wetland-dependent
	Mallard	*Anas platyrhynchos*	wetland-dependent
	Green-winged Teal	*Anas crecca*	wetland-dependent
Phasianidae	Ring-necked Pheasant	*Phasianus colchicus*	upland
Charadriidae	Killdeer	*Charadrius vociferus*	
Scolopacidae	Western Sandpiper	*Calidris mauri*	wetland-dependent
	Least Sandpiper	*Calidris minutilla*	wetland-dependent
Laridae	Glaucous-winged Gull	*Larus glaucescens*	
Alcedinidae	Belted Kingfisher	*Ceryle alcyon*	wetland-dependent
Picidae	Downy Woodpecker	*Picoides pubescens*	
	Northern Flicker	*Colaptes auratus*	
Tyrannidae	Willow Flycatcher	*Empidonax traillii*	
	Pacific-slope Flycatcher	*Empidonax difficilis*	
Hirundinidae	Violet-green Swallow	*Tachycineta thalassina*	
	Barn Swallow	*Hirundo rustica*	
Corvidae	Northwestern Crow	*Corvus* caurinus	
Paridae	Black-capped Chickadee	*Parus atricapillus*	
	Chestnut-backed Chickadee	*Parus rufescens*	
Troglodytidae	Bewick's Wren	*Thryomanes bewickii*	
Sylviidae	Ruby-crowned Kinglet	*Regulus calendula*	
Turdidae	Swainson's Thrush	*Catharus ustulatus*	
	American Robin	*Turdus migratorius*	
Bombycillidae	Cedar Waxwing	*Bombycilla cedrorum*	
Sturnidae	European Starling	*Sturnus vulgaris*	
Emberizidae	Orange-crowned Warbler	*Vermivora celata*	
	Black-throated Gray Warbler	*Dendroica nigrescens*	upland
	Wilson's Warbler	*Wilsonia pusilla*	
	Spotted Towhee	*Pipilo maculatus*	
	Savannah Sparrow	*Passerculus sandwichensis*	
	Song Sparrow	*Melospiza melodia*	
Icteridae	Red-winged Blackbird	*Agelaius phoeniceus*	wetland-dependent
	Brown-headed Cowbird	*Molothrus ater*	
Fringillidae	Purple Finch	*Carpodacus purpureus*	
	House Finch	*Carpodacus mexicanus*	

[19] The Schel-chélb bird species list follows the American Ornithologists' Union Checklist of North American Birds (AOU 1998). The list incorporates changes made in the 42nd Supplement to the Checklist, as published in the Auk 117:847-858, 2000.

Family Name	Common Name	Scientific Name	Status
Fringillidae	Pine Siskin	*Carduelis pinus*	
	American Goldfinch	*Carduelis tristis*	
Passeridae	House Sparrow	*Passer domesticus*	upland

Appendix E
Schel-chélb Benthic Macroinvertebrate Sampling Results

Benthic macroinvertebrates collected from the Schel-chélb estuary are classified to the lowest taxon possible following Plotnikoff and White (1996). Table E provides a list of macroinvertebrates identified from samples collected at the estuary in September 2001.

Table E **Benthic Macroinvertebrate Summary** (September 2001).

Order	Family	Common Name	Abundance	Relative Percent
Amphipoda	*Talitridae*	scud	4	0.6
Coleoptera	*Dytiscidae*	diving beetle	1	0.2
	Hydrophilidae	scavenger beetle	1	0.2
Collembola[20]	****	springtail	1	0.2
Diptera	*Ceratopogoniidae*	biting midges	3	0.4
	Chironomidae	midge	102	15.2
	Dixidae	dixa midges	2	0.3
	Empididae	dance fly	1	0.2
	Psycodidae	moth midges	1	0.2
	Sciomyzidae	marsh fly	1	0.2
Hemiptera	*Gerridae*	water strider	2	0.3
Isopoda	****	aquatic sow bugs	2	0.3
Megaloptera	*Sialidae*	alderfly	1	0.2
Mollusca	*Physidae*	pouch snails	3	0.4
	Planorbiidae	orb snails	1	0.2
Odonata	*Aeshnidae*	dragonfly	2	0.3
	Coenagrionidae	damselfly	1	0.2
Oligochaeta	****	worms	164	24.4
Ostracoda	****	seed shrimp	375	55.8
Plecoptera	*Nemouridae*	forest fly	1	0.2
Trichoptera	*Limnephilidae*	caddisfly	3	0.4
Total			**672**	**100%**

[20] Invertebrates in the *Collembola*, *Isopoda*, *Oligochaeta*, and *Ostracoda* taxa are not identified to family due to a lack of significant biological and taxonomical information beyond the tax level order for this region (Plotnikoff and White 1996).

Appendix F
Glossary of Terms

Abundance (total) – the total number of individuals, cover, frequency of occurrence, volume, or biomass of a species, or group of species, within a given area.

Accuracy – the closeness of a measured or computed value to its true value.

Adaptive management – the process of linking ecological management within a learning framework (Elzinga et al. 1998).

Aerial cover - is the amount of ground covered by vegetation of a particular species or suite of species when viewed from above. Aerial cover is generally expressed as a percentage. This is typically obtained from point-line, point-frame, or line intercept data.

Areal estimates - are made using the mapped boundary of a feature as viewed from above. Areal estimates are a measure of area recorded as a number from 0 to 100, and not as a fraction or percent (Hruby et al. 1999).

Aquatic vegetation - includes submerged and rooted (*Elodea*, *Characeae*, *Myriophyllum*) or floating (non-rooted) plants (*Lemna, Azolla, Wolfia*). For compliance purposes, these plants are not included in cover estimates. Vascular, rooted, floating-leaved plants *are* included in cover estimates (e.g., *Nuphar, Potamogeton*).

Bare ground - an area that can support, but does not presently support vascular vegetation.

Confidence interval (CI) – is an estimate of precision around a sample mean. A confidence interval includes confidence level and confidence interval half-width. Expressed as: CI 0.80 ± 0.20.

Canopy cover - the coverage of foliage canopy (herbaceous or woody species) per unit ground area**.**

Community - a group of populations of species living together in a given place and time.

Herbaceous - with characteristics of an herb; an annual, biennial, or perennial plant that is leaflike in color or texture, or not woody.

Hydric soils - soils formed under the conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register 1994).

Invasive – A plant that interferes with management objectives on a specific site at a specific point in time (Whitson et al. 2001).

Point frame – is a square or rectangular quadrat that consists of a set of identified points used to collect vegetation data.

Point Intercept Device – a tripod that contains a level and supports a rod that can also be leveled and then lowered vertically to intercept target vegetation at an identified point.

Point-line – linear series of points comprising a sample unit.

Point quadrat (points) –a single point, used to sample vegetation data. The point quadrat is theoretically dimensionless.

Population (biological) – all individuals of one or more species within a specific area at a particular time.

Population (statistical) - the complete set of individual objects (sampling units) about which you want to make inferences.

Precision – the closeness of repeated measurements of the same value.

Random sampling – sampling units drawn randomly from the population of interest.

Relative abundance – the number of individuals per unit of sampling effort.

Relative Cover - The proportion of specific target vegetative cover compared to that of all the vegetative species in the community combined (Brower et al. 1998).

Restricted Random Sampling Method – a sampling method that divides the population of interest into equal-sized segments. In each segment, a single sampling unit is randomly positioned. Sampling units are then analyzed as if they were part of a simple random sample (Elzinga et al. 1998).

Sample – a subset of the total possible number of sampling units in a statistical population.

Sample size equations –use sample unit mean and standard deviation to determine if data have been collected from enough sample units to meet the sampling objectives.

Sample standard deviation – a value indicating how similar each individual observation is to the sample mean.

Sampling – the act or process of selecting a part of something with the intent of showing the quality, style, or nature of the whole.

Sampling objective – a clearly articulated goal for the measurement of an ecological condition or change value (Elzinga et al. 1998). Sampling objectives are generated from success standards. Elements of a sampling objective include the desired confidence level

and confidence interval half-width, or the acceptable false-change error and acceptable missed-change error level.

Sample units – the individual objects that collectively make up a statistical population.

Standard deviation – a measure of how similar each individual observation is to the overall mean value.

Shrub - a woody plant which at maturity is usually less than 6m (20 feet) tall and generally exhibits several erect, spreading, or prostrate stems and has a bushy appearance (Cowardin et al. 1979).

Species richness - the total number of species observed on a site.

Structures - any structure that is not expected to support vegetation during the monitoring period. Structures may include habitat structures, rocks, and other artifacts.

Stratified Random Sampling Method- The population of interest is divided into two or more groups (strata) prior to sampling. Within each stratum the sample units are the same. Sample units from different strata may or may not be identical. Random samples are obtained within each group (Elzinga et al. 1998).

Systematic Random Sampling Method – the regular placement of quadrats, points, or lines along a sampling transect following a random start.

Transect - a line to survey the distributions or abundance of organisms across an area.

Tree - a woody plant that at maturity is usually 6m (20 feet) or more in height and generally has a single trunk, unbranched for 1m or more above ground, and more or less definite crown (Cowardin et al. 1979).

Vegetation structure - the physical or structural description of the plant community (e.g. the relative biomass in canopy layers), generally independent of particular species composition.

Wetland-dependent species (birds) - restricted in temporal or spatial distribution to wetlands based on an intrinsic feature or features of the environment (Finch 1989).

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